

Description

[FABRICATION METHOD FOR SHALLOW TRENCH ISOLATION REGION]

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of Taiwan application serial no.92108333, filed on April 11, 2003.

BACKGROUND OF INVENTION

[0002] Field of Invention

[0003] The present invention relates to a fabrication method for a shallow trench isolation region. More particularly, the present invention relates to a method for preventing void generation in a shallow trench isolation region.

[0004] Description of Related Art

[0005] The shallow trench isolation technique typically employs anisotropic etching to form a trench in a semiconductor substrate and filling an oxide material in the trench thereafter to form an isolation region for a device. The dimension of an isolation region formed by the shallow trench

isolation technique can be adjusted. Further, the problem of bird's beak resulted in the conventional LOCOS is prevented. Therefore, shallow trench isolation is a preferred isolation technique in the sub-micron metal oxide semiconductor process.

[0006] Along with the increase of the integration of integrated circuits, the device dimension also gradually decreases. As the dimension of a shallow trench isolation region is being reduced when the integration of integrated circuits increases, problems that are associated with a high aspect ratio, for example, an incomplete filling of the trench or void generation in the subsequently formed shallow trench isolation region, will eventually surface. The isolation capability of a shallow trench isolation region would become inferior, leading to problems, such as, current leakage and undesirable reliability of the device.

SUMMARY OF INVENTION

[0007] Accordingly, the present invention provides a fabrication method for a shallow trench isolation structure, wherein the generation of voids in the shallow trench isolation structure is avoided to prevent poor isolation capability in the shallow trench isolation structure.

[0008] The present invention further provides a trench filling

method, wherein the problem of an incomplete filling of the trench due to a high aspect ratio after the miniaturization of device is resolved.

[0009] The present invention provides a fabrication method for a shallow trench isolation region. This method comprises forming a mask layer over a substrate. Using the mask layer as an etching mask, the substrate is patterned to form a trench, wherein the trench comprises a first aspect ratio. A portion of the trench is filled with a first insulation layer, wherein the trench filled with the first insulation layer comprises a second aspect ratio, wherein the second aspect ratio is equal or smaller than the first aspect ratio. A first surface treatment process is performed to form a treated layer on the surface and sidewall of a part of the first insulation layer. In the present invention, the surface treatment process includes a tilted ion implantation process. Thereafter, a wet etching process is performed to remove the surface treated layer on the surface and sidewall of the first insulation layer. Further, the trench depth, after the removal of the treated layer, is substantially the same as that before the removal of the treated layer. However, the trench width, after the removal of the treated layer, is greater than that before the removal of

the treated layer. Therefore, after the removal of the treated layer, the trench comprises a third aspect ratio, wherein the third aspect ratio is smaller than the second aspect ratio. Thereafter, a second insulation layer is formed over the first insulation layer, filling the trench. The mask layer is subsequently removed to form a shallow trench isolation region.

[0010] The present invention also provides a trench filling method, wherein this method provides a substrate having an opening already formed therein. The opening comprises a first aspect ratio. A portion of the opening is filled with a first material layer, wherein after filling with the first material layer, the opening comprises a second aspect ratio. Further, the second aspect ratio is equal or smaller than the first aspect ratio. Thereafter, a treated layer is formed on the surface of a part of the first material layer. In the present invention, the treatment process is, for example, a tilted ion implantation process. A wet etching process is then performed to remove the surface treated layer. The depth of the opening is substantially the same before and after the removal of the treated layer. However, the width of the opening, after the removal of the treated layer, is wider than the width of the opening

before the removal of the treated layer. Therefore, subsequent to the removal the treated layer, the opening comprises a third aspect ratio. Further, the third aspect ratio is smaller than the second aspect ratio. Thereafter, a second material layer is formed over the first material layer to fill the opening.

[0011] In accordance to the present invention, filling a portion of the opening with a first material layer followed by removing a portion of the first material layer can lower the aspect ratio of the opening. Therefore, the present invention can mitigate the problem of an incomplete trench filling due to a high aspect ratio.

[0012] The fabrication method for a shallow trench isolation region further prevents the generation of voids. Therefore, the shallow trench isolation region formed provides a more desirable isolation effect.

[0013] It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF DRAWINGS

[0014] The accompanying drawings are included to provide a further understanding of the invention, and are incorpo-

rated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

[0015] Figures 1A to 1G are schematic, cross-sectional views illustrating the process flow for fabricating a shallow trench isolation region according to one aspect of the present invention.

DETAILED DESCRIPTION

[0016] Figures 1A to 1G are schematic, cross-sectional views illustrating the process flow for fabricating a shallow trench isolation region according to one aspect of the present invention.

[0017] Referring to Figure 1A, a pad oxide layer 102 and a mask layer 104 are formed over a substrate 100. The pad oxide layer 102 and the mask layer 104 are formed by, for example, performing a thermal oxidation process to form a thin oxide layer (not shown) on a surface of the substrate 100, followed by depositing a silicon nitride layer on the thin oxide layer and performing photolithography and etching to pattern the silicon nitride layer to form the mask layer 104. Further using the mask layer 104 as an etching mask, an etching process is performed to pattern

the thin oxide layer and the substrate 100 to form the pad oxide layer 102 and a trench 106. The trench 106 comprises a depth "H" and a width "W". The aspect ratio of the trench 106 is "H/W".

[0018] Referring to Figure 1B, an insulation layer 108 is formed over the substrate 100, wherein the insulation layer 108 partially fills the trench 106. The thickness of insulation layer 108 is about 20% to 30% of the depth of the trench 106. The trench that is subsequent to the filling of the insulation layer 108 is depicted with the reference number 106a, wherein the trench 106a has a height "H'", a width "W'" and an aspect ratio "H'/W'". Further, the aspect ratio "H'/W'" of the trench 106a is smaller than the aspect ratio "H/W" of the trench 106. In one aspect of the present invention, the insulation layer 108 is formed with a material that includes silicon oxide. Further, The insulation layer 108 is formed by a method, such as, chemical vapor deposition, and preferably, a high density plasma chemical vapor deposition method.

[0019] Continuing to Figure 1C, a surface treatment step 110 is performed to form a treated layer 112 on the surface of the insulation layer 108. The surface treatment step 110 includes, for example, a tilted ion implantation process.

Further, the tilted ion implantation process is conducted at an angle of about 30 degrees to about 60 degrees. The dopants used in the tilted ion implantation process comprise, for example, an nitrogen gas, an argon gas or other inert gas. In addition, the tilted angle ion implantation process is conducted at an energy level of about 20 KeV to about 100KeV with a dopant concentration of about $1\text{E}15/\text{cm}^2$ to about $1\text{E}16/\text{cm}^2$.

[0020] Since the implanted angle in the above surface treatment process 110 is about 30 degrees to about 60 degrees, only a portion of the surface of the insulation layer 108 is implanted with dopants to form a treated layer 112. Further, the treated layer 112 and the insulation layer 108 have different etching rates. If the dopants used in the above tilted ion implantation process is nitrogen, the etching rate of the treated layer 112 is about 155 to 165 angstroms/minute. If the dopants used in the above tilted ion implantation process is argon, the etching rate of the treated layer 112 is about 195 to 205 angstroms/minute, whereas the etching rate of the insulation layer 108 without any implanted dopants is about 120 to 125 angstroms/minute.

[0021] Referring to Figure 1D, an etching, preferably a wet etch-

ing process, is performed to remove the treated layer 112 on the surface of the insulation layer 108. The trench, after the removal of the treated layer 112, is designated with the reference number 106b. The trench 106b has a depth "H'", a width "W'", and an aspect ratio "H'/W'". One point that is worth noting is that the depth "H'" of the trench 106b is substantially the same as the depth "H'" of the trench 106a. However, the width "W'" of the trench 106b is greater than the width "W'" of the trench 106a. In other words, there is no significant change in the depth of the trench before and after the removal of the treated layer 112. However, after the removal of the treated layer 112, the width of the trench is increased. Therefore, the aspect ratio "H'/W'" of the trench 106b is smaller than the aspect ratio "H'/W'" of the trench 106a. As a result, to fill the trench 106b with an insulation material, the trench 106b can be filled completely.

[0022] Referring to Figure 1E, an insulation layer 114 is formed filling the trench 106b, wherein the insulation layer 108a and the insulation layer 114 together serve as an insulation material layer 116 for the shallow trench isolation region. In this aspect of the present invention, the insulation layer 114 is, for example, silicon oxide. Further, forming

the insulation layer 114 includes, for example, performing chemical vapor deposition, and preferably, high density plasma chemical vapor deposition.

[0023] As discussed in the above, the aspect ratio H/W of the trench 106b is significantly reduced compared to the aspect ratio H/W of the trench 106a. Therefore, in accordance to the fabrication method of the present invention, the trench can be completely filled with the insulation material layer 116 without the formation of voids therein.

[0024] As shown in Figure 1F, the insulation material layer 116 is partially removed until the mask layer 104 is exposed. Removing a portion of the insulation layer 116 includes performing chemical mechanical polishing or etching back.

[0025] As shown in Figure 1G, the mask layer 104 and the pad oxide layer 102 are removed to complete the fabrication of a shallow trench isolation region.

[0026] The fabrication method for a shallow trench isolation region of the present invention comprises filling a part of the trench of the first insulation layer, followed by removing a portion of the first insulation layer to lower the aspect ratio of the trench. The trench is then completely filled. Therefore, in accordance to the present invention, the trench can be completely filled without the formation

of voids. The shallow trench isolation region can thus provide a superior isolation capability.

[0027] By improving the trench filling effect of the insulation material during the fabrication of a shallow trench isolation region of the present invention, the generation of voids in the isolation region is effectively prevented. Therefore, to lower the aspect ratio of an opening by filling a material layer into a part of the opening followed by removing a portion of the material layer can be applied to other filling processes, other than the shallow trench isolation process, for example, the filling process with an organic material or a metal material.

[0028] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.